Geometric Techniques for Trajectory Planning & Chaos Control of a Bio-Inspired Autogenetic Capsule Robot

Bournemouth University

PhD Student: Pengcheng Liu (pliu@bournemouth.ac.uk)
Supervisor Team: Prof. Hongnian Yu & Dr. Shuang Cang

INTRODUCTION

http://pixgood.com/snow-leopard-hunting.html

http://wordlesstech.com/2011/02/23/hawk-chases-a-rabbit/

Research

Bio-inspired Underactuated Robotics ∩ Applied Control Theory

- High Speed
- Ultra-Efficiency
- Super-Maneuverability
- Extreme-Agility

Highly Dynamic Robots

Needed in Society

- Unstructured / Remote / Unsafe Environments
- Disaster Response, First Response, Smart Bionics

Technological Capability

- Advances in Sensor / Actuator / Power / Computing Technologies / Mechanism Design Technologies

Project Aims & Objectives

- Investigating the challenges and the prospects of bio-inspired underactuated robots in various environments;
- Shedding light on the elaborate utilization of the bio-inspired characteristics;
- Monitoring and controlling the qualitative changes of system dynamics;
- Designing the robust adaptive controller to induce limit cycle motions.

CHALLENGES

Challenges all along remained are

- Hard-to-model (unknown models/principles)
- Controllability & maneuverability
- Effective underactuation
- Nonlinear dynamics & strong coupling
- Hybrid dynamics (impacts, frictions, contact conditions)
- Design of controllers that induce limit cycles rotation / hopping

Autogenetic Capsule Robot

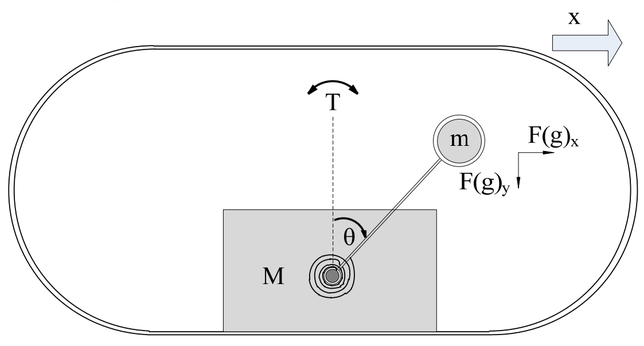

Fig. 1 Layout of the proposed capsule system

Nonlinear Analysis

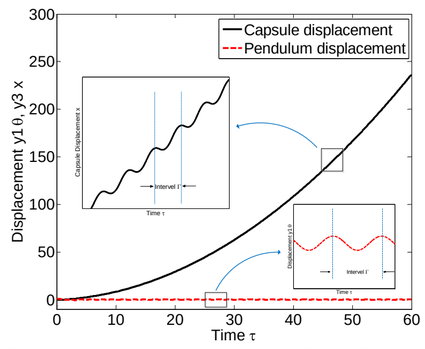

Fig.2 Typical time histories of angular displacement of the pendulum and the progression of the capsule

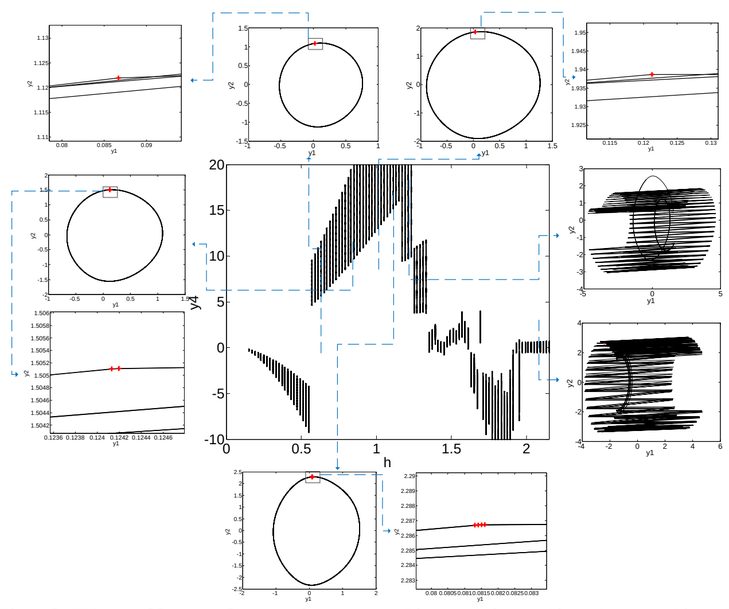

Fig. 3 The effect of varying nondimensionalized amplitude

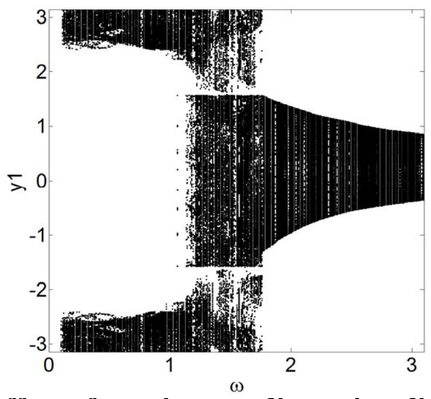

Fig. 4 The effect of varying nondimensionalized frequency

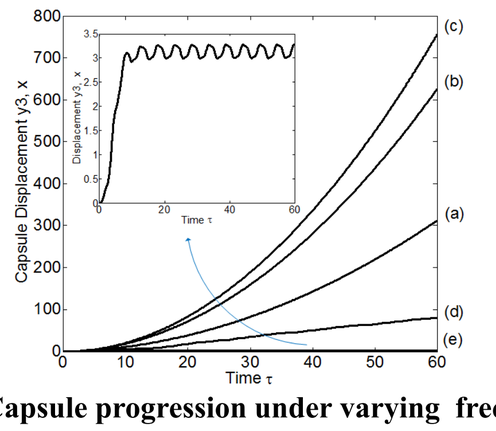

Fig. 5 Capsule progression under varying frequency

Synchronized Trajectory Generation

- Viscoelasticity profile
- Inverted pendulum motion profile

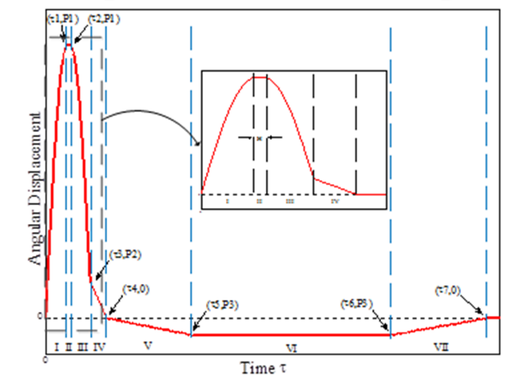

Fig. 6 Synchronized desired trajectory profile

Simulation Results

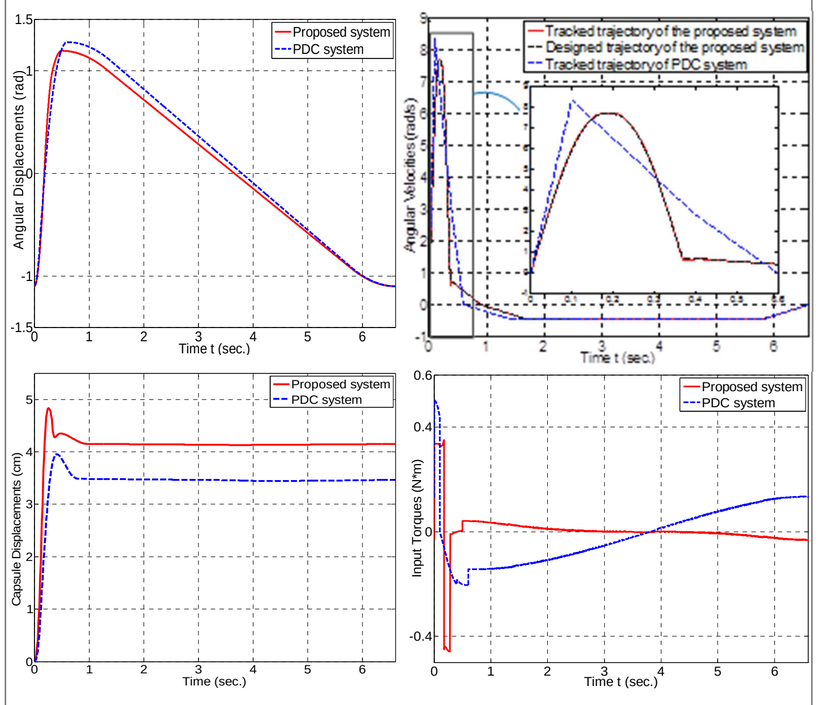

Fig. 7 Time histories of (a) the angular displacements, (b) capsule displacements, (c) periodic trajectories and (d) input torques under closed-loop control for one full cycle

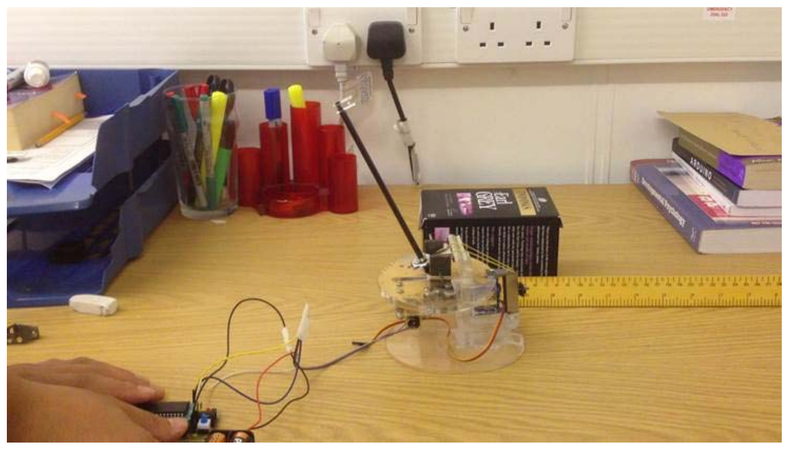

Fig. 8 The first generation prototype

APPLICATIONS

- Pipeline inspections
- Medical diagnosis assistants
- Rescue robot (environment investigations)
- Industrial robot
- Space robot
- Military robot

REFERENCES

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[2] Y. Liu, H. Yu and T. Yang, "Analysis and Control of a Capsubot," Proceedings of the 17th IFAC WorldCongress, Seoul, South Korea, 6-11 July, 2008.
[3] Y. Liu, M. Wiercigroch, E. Pavlovskaia and H. Yu, "Modelling of a Vibro-Impact Capsule System", International Journal of Mechanical Sciences, Vol. 66, January 2013, Pages 2–11.
[4] Y. Liu and H. Yu, "Survey of Underactuated Mechanical Systems", Control Theory & Applications, IET, Vol. 7, Issue 7, 2013.